C. Faraday's Law in differential form is

$$\vec{\nabla} \times \vec{\mathbf{E}} = -\frac{\partial \vec{\mathbf{B}}}{\partial t}$$

Stokes' theorem says that the following integral relationship is also true:

$$\oint \vec{\mathbf{E}} \cdot d\vec{\ell} = -\frac{d}{dt} \iint \vec{\mathbf{B}} \cdot d\vec{\mathbf{a}}$$

What would be an analogous integral expression involving the vector potential $\vec{\mathbf{A}}$ and the magnetic field $\vec{\mathbf{B}}$, given that $\vec{\nabla} \times \vec{\mathbf{A}} = \vec{\mathbf{B}}$?

Combine this integral relationship between $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$ from above with Faraday's law in integral form to find an integral relationship between $\vec{\mathbf{E}}$ and $\vec{\mathbf{A}}$.

Part 2: Gauge invariance

D. If $\oint \vec{\mathbf{E}} \cdot d\vec{\ell} = 0$ says that $\vec{\mathbf{E}} = -\vec{\nabla} V$, use the integral relationship you derived on the previous page between $\vec{\mathbf{E}}$ & $\vec{\mathbf{A}}$ to show that

$$\vec{\mathbf{E}} + \frac{\partial \vec{\mathbf{A}}}{\partial t} = -\vec{\nabla} V$$

Is this relationship also true in time-*independent* situations?
Why or why not?

Suppose we have two vector potentials $\vec{\mathbf{A}}$ & $\vec{\mathbf{A}}'$, such that

$$\vec{\mathbf{A}}' = \vec{\mathbf{A}} + \vec{\nabla}\lambda$$

(This shift of the vector potential is part of what is called "changing the gauge") Is it also true that $\oint \vec{\mathbf{A}} \cdot d\vec{\ell} = \oint \vec{\mathbf{A}}' \cdot d\vec{\ell}$? Why or why not?

Challenge Question: We showed in the previous Tutorial (part B) that changing **A** in this way, $\vec{\mathbf{A}}' = \vec{\mathbf{A}} + \vec{\nabla}\lambda$, does not affect the **B** field.
Does it affect the **E** field?